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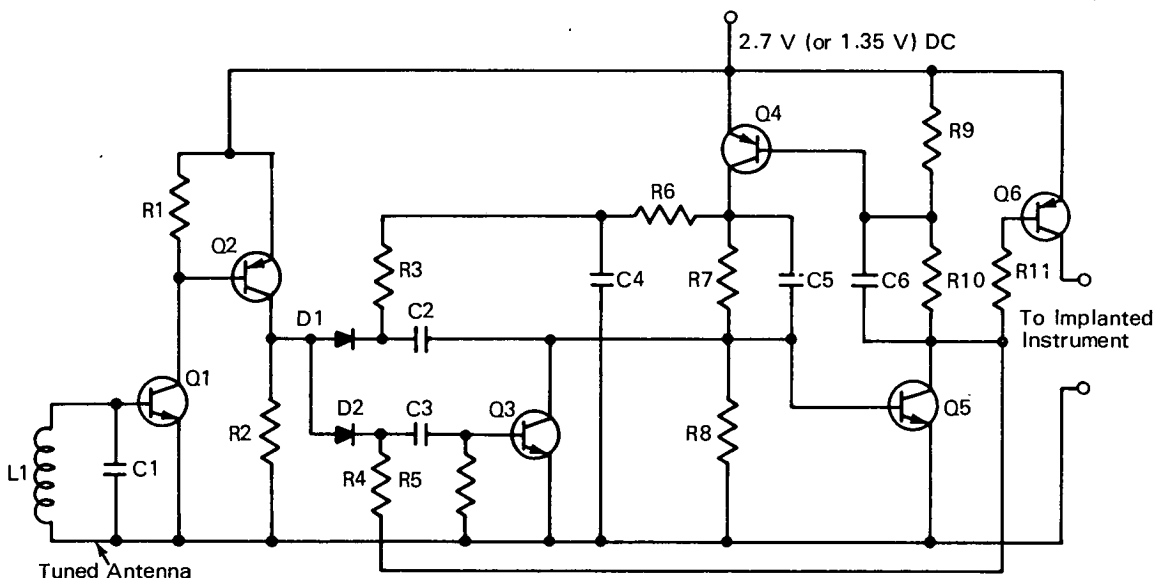
## RF-Controlled Implantable Solid State Switch

### The problem:

To provide a remotely activated switch for bio-telemetry systems that are totally implanted in an animal and are powered by short-lived batteries.

### How it's done:

A tuned antenna (tank circuit L1, C1) within the implanted circuitry receives the transmitted actuating rf pulse (typically about 2.8 MHz) from an



Magnetically controlled latching switches are often employed for this purpose, but it is not always possible to bring a magnet sufficiently close to the switch in order to activate the latch. Moreover, the latches are often spuriously triggered by metallic objects within the vicinity. State-of-the-art radio telemetry switches are not useful because they consume power in the off position.

### The solution:

A miniature, implantable, solid state, rf-controlled switching circuit (see schematic) which consumes zero power in the off condition and can be turned on or off by a pulse of rf energy.

external source, and the pulse is rectified and amplified. The amplified pulse activates a normally off complementary bistable multivibrator, which turns on the switch between the implanted battery power source and the instrument. The switch stays on until a second transmitted rf pulse activates a circuit which shorts one active element of the bistable multivibrator and thereby drives both active elements of the multivibrator to their off state. Electric current between the battery power source and the instrument is thus terminated.

The threshold voltage of Q1 is approximately 0.5 V at room temperature. The positive portions of the

(continued overleaf)

received signal which are higher than this threshold voltage are rectified and amplified by Q1 as the signal is applied to Q1's base. The collector voltage of Q1 drops from the power supply voltage (typically 1.35 or 2.70 V, depending on whether one or two mercury cells are used) to a fraction of a volt. As the base voltage envelope decays exponentially, in compliance with the transmitted rf pulse, the collector voltage rises exponentially back up to the power supply voltage. Because of the threshold voltage, a strong rf signal is required to induce circuit response, thus rendering the switch insensitive to electrical noise.

The voltage drop across R1 turns on transistor Q2 and the voltage drop across R2 forward-biases diode D1. Diode D2, whose cathode is connected through R4 to the normally off transistor Q5, remains back-biased. The initially uncharged capacitor C2 transmits the Q1 collector voltage change to the base of NPN transistor Q5, turning it on. The Q5 collector current momentarily pulses through R9 and C6 and turns on Q4. The pulsed Q4 collector current then flows through initially uncharged C5 and resistor R8. As a result, the base-emitter junction of Q5 is additionally forward-biased. When C5 is fully charged, collector current from Q4 flows through R7, R8, and the Q5 base-emitter junction. Similarly, when C6 is fully charged, collector current from Q5 flows through R9, R10, and the Q4 base-emitter junction. Thus, turning on Q4 and Q5 by a pulse provides a regenerative action which saturates both Q4 and Q5.

The Q5 collector voltage is applied to the base of Q6 via resistor R11. When the Q5 collector voltage drops, Q6 turns on and saturates, providing a low impedance path for power flow to an implanted instrument connected to the Q6 collector.

Current flowing to the implanted instrument can be interrupted with an rf pulse which turns off Q6. As indicated above, the rf pulse results in the satu-

ration of Q2. However, since Q5 is now on and its collector is essentially at ground potential, diode D2 becomes forward-biased and diode D1 is back-biased. The voltage drop across R4 and R5, due to a current pulse through D2, turns on and saturates the normally off NPN transistor Q3, causing it to acquire a collector-to-emitter voltage of about 0.2 V. This short-circuits the Q5 base-emitter junction, turning Q5 off and Q4 on. Q6 assumes the high-impedance state which shuts off power to the instrument connected to the Q6 collector. Transistor Q3 shuts off when capacitor C3 is fully charged, and the entire switching circuit thus becomes quiescent, consuming no power while off.

#### Notes:

1. The components of the switch (exclusive of batteries) can be "cord-wooded" into the size of a small coin. The size of the circuit can be reduced even further by integrated circuit techniques.
2. Some variations of the basic circuit have been built, but only the one described consumes no power in the standby mode.
3. Requests for further information may be directed to:

Technology Utilization Officer  
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Reference: TSP71-10426

#### Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

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